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(54) **Electrochemical cell and method of producing electrical energy through electrochemical reaction in a fuel cell.**

(57) A fuel cell system wherein incoming process gas to the cell is provided by adjustably combining respective amounts of outgoing heated process gas and fresh supply gas via a means responsive to the temperature of the former gas to maintain the fuel cell at a predetermined temperature.

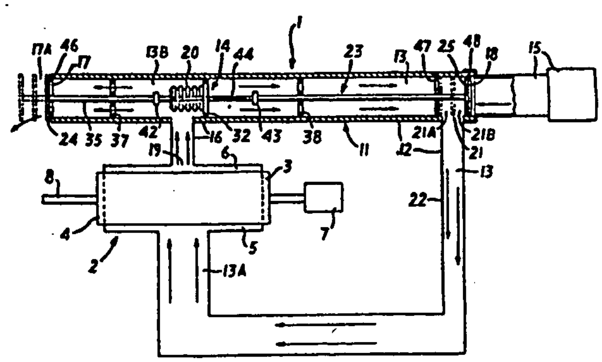

FIG. 1

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Electrochemical cell and method of producing electrical energy through electrochemical reaction in a fuel cell.

This invention relates to the electrochemical cells, and in particular, to electrochemical cells provided with thermal control.

In the design of electrochemical cells, such as fuel cells and batteries of the type wherein reactant or process gas is conducted to the cells for electrochemical reaction, thermal control is a dominant factor. One seemingly desirable technique for realizing such control involves the utilization of the sensible heat from the process gas itself. In this technique the incoming process gas may be supplied to the fuel cell at a temperature below the desired cell operating temperature and at a flow level above that required to obtain a preselected cell output power. The additional process gas at the lower temperature then acts to remove heat simply by increasing its temperature during passage through the cell. In this type of system, it is also usual to recover unused outgoing heated process gas and, after suitable cooling and water removal, add same to the fresh supply gas to provide the required in-flow of process gas to the cell.

U.S. patent 3,198,664 discloses a typical system of the aforesaid type. A vastly improved system of this type is disclosed in U.S. patent application Serial No. 923,363 assigned to the same assignee.

While the last mentioned system successfully provides temperature control, alternative systems are still being investigated.

It is an object of the present invention to provide an electrochemical cell system wherein thermal control is effected in a simple, passive and automatic manner.

It is a further object of the present invention to provide a fuel cell system wherein automatic and simple thermal control is provided during operating periods and automatic hermetic sealing during non-operating periods.

Summary of the Invention

In accordance with the principles of the present invention, the above and other objectives are realized in an electrochemical cell system and method wherein the incoming process gas to the cell is provided by combining a first amount or flow level of heated process gas outgoing from the cell with a second amount or flow level of fresh supply process gas, and by adjusting these first and second amounts to maintain the cell at a predetermined temperature. The adjustment of the first and second amounts of outgoing heated process gas and fresh supply gas is via a temperature sensitive means which is responsive to the temperature of the heated gas.

In the particular embodiment of the invention to be disclosed hereinafter, a conduit means having a passage in communication with the input and output manifolds of the cell and with the source of fresh supply gas is provided. The temperature sensistive means is in the form of a charged bellows whose expansion and contraction controls a damper assembly which effects passage of the first and second amounts of the heated process gas and supply gas through the conduit passage to the cell input manifold.

Brief Description of the Drawing

The above and other features and aspects of the present invention will become more apparent upon reading the

following detailed description in conjunction with the accompanying drawings, in which:

FIG. 1 illustrates schematically an electrochemical cell system in accordance with the principles of the present invention; and

FIG. 2 shows in greater detail the temperature control system of the cell system of FIG. 1.

Detailed Description

In FIG. 1, electrochemical cell system 1 comprises a fuel cell stack 2 having corresponding sets of input and output manifolds 3 and 4 and 5 and 6, respectively, serving the anode and cathode sides of the stack. Input manifold 3 receives process gas (fuel gas) from a fuel supply 7 and conveys same as incoming fuel gas to the stack 2. Unused outgoing fuel gas is expelled through output manifold 4 to an exhaust conduit 8. Further process gas (oxidant gas) is received by the input manifold 5 which conveys same as incoming oxidant gas to the stack, while unused oxidant gas outgoing from the cell is expelled from the output manifold 6.

Attendant the operation of the stack 2 to provide a predetermined or desired output electrical power through electrochemical reaction of the fuel and oxidant gases, is the production of heat which increases with continued cell operation. This heat, if not maintained at a predetermined temperature associated with the desired cell output power, will cause a reduction in output power and eventual destruction of the stack 2. Accordingly, a temperature control system 11 is provided to ensure maintenance of the cell temperature at the predetermined level.

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In accordance with the principles of the present invention, the system 11 provides temperature control through forming the incoming process gas from a combination of respective amounts of outgoing heated process gas and fresh supply process gas, these amounts being automatically adjusted to ensure cell temperature at the predetermined level. In the present illustrative example, temperature control is brought about by forming the incoming oxidant process gas from first and second amounts of outgoing heated oxidant process gas and fresh supply oxidant process gas. However, it is within the contemplation of the invention to provide such control by establishing the incoming fuel process gas or both the incoming fuel process gas and the incoming oxidant process gas in such manner. Where fuel process gas control is to be provided, a system similar to that to be described for the system 11 can be used.

The system 11 comprises a conduit 12 having a passage 13 whose one end 13A communicates with the input manifold 5 and whose other end 13B communicates with the output manifold 6. Temperature responsive means 14 situated in the passage 13 is responsive to the temperature of the outgoing heated oxidant gas from the output manifold 6 and controls the amount of such gas and the amount of fresh supply oxidant gas from a supply 15 to be coupled to the passage end 13A and, therefore, to the input manifold 5.

More particularly, referring both to FIGS. 1 and 2, the conduit 12 comprises a first conduit section 16 having first and second ports 17 and 18 at its opposite ends, the port 18 being fed by the supply 15 and the port 17 serving to exhaust the portion of the outgoing heated oxidant

gas not utilized to form the incoming oxidant gas. Third and fourth ports 19 and 21 are also provided in the section 16. The port 19 communicates with the output manifold 6 and receives the outgoing heated oxidant gas from the stack 2. The port 21 couples respective portions of the outgoing heated oxidant gas and the fresh supply oxidant gas to a second conduit section 22. Conduit section 22 extends from the port 21 to the input manifold 5.

Temperature responsive means 14 controls the relative amounts of outgoing heated oxidant gas and fresh supply oxidant gas coupled through port 21 by adjusting the respective access regions 21A and 21B of the port 21, and by simultaneously adjusting the exhaust region 17A of the exhaust port 17. More particularly, the control means 14 comprises a fluid charged bellows 20 which operates a damper assembly 23 comprised of first and second dampers or plates 24 and 25 situated adjacent the ports 17 and 21, respectively. Damper 24 is of area sufficient to totally block the port 17 when in abutting relationship thereto. As shown, the damper is disposed exterior to the section 12 and defines with the port 17 the exhaust region 17A. Damper 25, in turn, is of area equal to the cross sectional area of the section 12 and defines with the port 21 the access regions 21A and 21B.

As seen more clearly in FIG. 2, the damper assembly further includes component structure for supporting the dampers 24 and 25 and for interconnecting same to the bellows 20. Thus, first and second tie rod assemblies 26 and 27 connect the dampers 24 and 25 to a yoke assembly 28 which is connected through an acutaing rod 29 to an acutator plate 31

carried by the free end 20A of the bellows 20. The other end 20B of the bellows is held fixed by a support plate 32 which is rigidly held against the inner wall of the section 16. The tie rod assemblies 26 and 27 are of similar construction and comprise first rod sections 33, 34 connected to the respective dampers and second rod sections 35, 36 connected to the yoke assembly. Bearing plates 37, 38 slidably support the rod sections 33, 34 to permit adjustment of the tie rod length. The rod sections 35, 36 connect to yoke assembly transverse members 42, 43 which, in turn, are coupled by connecting rods 44, 45. The latter pass through apertures 32A, 32B in the support plate 32, while the transverse member 42 is further connected to the actuating rod 29.

As further shown in FIG. 1, an O-ring 46 is provided in contiguous relationship with the inner wall of the section 16 at the port 17 to provide an effective seal when the damper 24 is in engaging relationship with the port. Similarly, O-rings 47, 48 are provided contiguous the section 16 inner wall adjacent opposite ends of the port 21. These rings are engaged by the damper 25 when at such port ends to thereby effect a gas seal thereat.

As above-indicated, the temperature control system 11 provides control of the stack 2 temperature by controlling the respective amounts of outgoing oxidant gas and oxidant supply gas coupled through the access regions 21A and 21B and combined in the conduit 12 for passage to the passage end 13A adjacent the cell input port 5. In practice, the bellows is designed to undergo expansion at a temperature

above the minimum reaction temperature of the cell. A typical temperature at which bellows expansion begins might be 250°F for a cell having a minimum reaction temperature of 225°F. Moreover, the conduit sections 16 and 22 are selected to establish flow in excess of that required for electrochemical reaction at the predetermined cell temperature which might, for example, be 325°F. The oxidant supply is typically air, preferably, at ambient temperature (e.g., about 72°F).

In operation, the fuel cell stack 2 is initally at rest with no process gas flow therethrough and, thus, in an unheated condition. The oxidant gas at the bellows is, therefore, likewise unheated and the bellows 20 is in its maximum contracted position. In this position, the actuating rod 29 and yoke assembly 28 move the respective rod assemblies 26 and 27 rightward thereby moving the dampers 24 and 25 into sealing engagement with the O-rings 46 and 48. The access regions 17A and 21B are thereby reduced to zero expanse and the access region 21A to maximum expanse. In this condition, the cathode side of the stack 2 is placed in an hermetically sealed condition.

To bring the fuel cell into operation, the oxidant gas initially in the conduit 22 is preheated by a heat exchanger (not shown) situated in the conduit line to the cell reaction temperature and a blower (also not shown) in the line 22 causes circulation of the heated oxidant gas and, therefore, application of the gas as incoming oxidant gas to the stack 2. Fuel gas is then supplied to the stack 2 manifold for passage through the stack.

Due to electrochemical reaction, the stack 2 produces electrical energy from the incoming oxidant and

fuel gases. As a product of this reaction, heat is generated by the cell causing a heating of unused oxidant gas outgoing from the cell through manifold 6. This gas passes through the port 19 into the conduit 16 and, in doing so, contacts the bellows 20, which, in the case shown, is directly above the port 19. Since the bellows does not begin to expand until raised to a temperature above the stack minimum reaction temperature, the bellows remains in its contracted position as initial outgoing heated oxidant gas passes through the conduit 16. At this time, the dampers 24 and 25 remain in their initial positions, maintaining the access region 21A at its maximum expanse and the access region 21B and exhaust region 17A at their minimum zero expanses.

As the stack 2 continues to operate, the stack 2 temperature increases above the temperature at which the bellows 20 expands. At this point, the outgoing oxidant gas, which now also is at this increased temperature, in contacting the bellows causes expansion thereof. Such expansion results in leftward movement of the free end 20A of the bellows and, accordingly, leftward movement of the dampers 24 and 25 through actuating rod 29, yoke assembly 28 and rod assemblies 26 and 27. The dampers are thus moved leftward of the O-rings 46 and 48, causing the exhaust region 17A to increase from its minimum zero expanse and the access region 21A to decrease from its maximum expanse. A portion of the outgoing heated oxidant gas is thus expelled from the conduit 16 through the region 17A, while the remaining part is carried by the conduit to the access region 21A. At the same time, the access region 21B is increased from its minimum zero expanse allowing fresh supply oxidant gas to pass through this region.

The heated oxidant gas and the fresh supply gas pass through the respective regions 21A and 21B and into the conduit 22. The gases are combined therein to form a composite gas which is now at a lower temperature than the outgoing heated oxidant gas, the combined gas being conveyed by the conduit 22 to the manifold 5 as incoming oxidant gas.

The aforesaid process continues until the bellows expands to a position whereat the dampers 24 and 25 are positioned to provide an exhaust region 17A and access regions 21A and 21B of expanses which proportion the amounts of heated oxidant gas returned and exhausted and the amount of fresh supply gas taken in to result in a temperature equilibrium in the stack at the preselected temperature. When this condition ensues, the stack temperature remains at the preselected temperature and the heated outgoing oxidant gas ceases to increase in temperature. The bellows thus stops expanding and maintains the equilibrium positions of the dampers 24 and 25 and, therefore, the respective relationship of the regions 17A, 21A and 21B. The amount of heated outgoing oxidant gas and fresh supply gas combined in the conduit 22 is thereby held constant, as is temperature of the combined gas as it is applied to the cell at the input manifold 5.

Any additional increases in temperature of the cell are now manifested as temperature increases in the outgoing heated oxidant gas which causes further expansion of the bellows 20. This results in further increasing the expanse of exhaust region 17A, further decreasing the expanse of access region 21A, and further increasing the expanse of access region 21B. Less heated outgoing oxidant gas and

additional fresh supply gas at the lower temperature are thereby fed into the conduit 22, whereby the temperature of the composite gas is lowered sufficiently to lower the stack temperature. This continues until the stack temperature returns to the preselected temperature, at which time the bellows will have contracted and moved the dampers to their respective equilibrium positions.

If the stack temperature now should decrease below the preselected temperature, the opposite operation occurs. Thus, the bellows is further contracted causing rightward movement of the dampers, thereby decreasing the expanses of regions 17A and 21B and increasing the expanse of region 21A. This reduces the amount of outgoing oxidant gas exhausted, increases the amount of such gas recirculated and decreases the amount of fresh supply oxidant gas taken in. The composite gas in conduit 22 is thus increased in temperature, thereby increasing the stack 2 temperature. Again this continues until the stack 2 temperature is at the preselected temperature, at which temperature the bellows brings the dampers to their equilibrium positions.

As can be appreciated, the temperature control system 11 of the invention thus acts to control temperature of the stack 2 by adjusting the relative amounts of outgoing heated oxidant gas and lower temperature fresh supply gas which are combined for use as incoming oxidant gas to the stack. Once equilibrium is reached, temperature control occurs through raising and lowering the temperature of the composite gas whose flow remains essentially constant but whose relative proportions of heated and fresh supply oxidant gas varies. Moreover, the aforesaid variation occurs automatically through a bellows and damper assembly which with

the stack inoperative also provides hermetic sealing.

With the present system, the fresh supply of oxidant gas need not itself be heated, since heating occurs through combination with the outgoing heated oxidant gas. Thus, as above-indicated, the fresh supply may be at ambient temperature.

The bellows utilized with the present invention may be gas, liquid or otherwise charged and may be biased so as to provide expansion at the required temperatures.

In all cases, it is understood that the above-described arrangements are merely illustrative of the many possible specific embodiments which represent applications of the present invention. Numerous and varied other arrangements can readily be devised in accordance with the principles of the present invention without departing from the spirit and scope of the invention.

What is Claimed Is

1. An electrochemical cell system comprising: a fuel cell having a cathode section and an anode section for receiving incoming process gases, respectively; and means for maintaining said fuel cell at a first predetermined temperature comprising: means for combining a first amount of heated process gas outgoing from one of said sections with a second amount of fresh supply process gas to form said incoming process gas for said one section; and means responsive to the temperature of said outgoing heated process gas from said one section for adjusting said first and second amounts to maintain the temperature of said fuel cell at said first predetermined temperature.

2. A system in accordance with claim 1 wherein: said supply gas is at a temperature below that of said heated process gas.

3. A system in accordance with claim 2 wherein: said supply gas is at ambient temperature.

4. A system in accordance with claim 1 wherein: the flow of said incoming process gas to said one section is maintained at a substantially constant level.

5. A system in accordance with claim 4 wherein: said flow level is above that required to provide a predetermined output potential of said fuel cell at said first predetermined temperature.

6. A system in accordance with claim 1 wherein: said temperature responsive means is responsive to temperatures equal to or above a preselected second temperature which is above the reaction temperature of the fuel cell.

7. A system in accordance with claim 1 wherein: said first and second amounts are adjustable to substantially zero.

8. A system in accordance with claim 1 wherein: said one section is one of said anode and cathode section.

9. A system in accordance with claim 1, wherein: said combining means comprises: a conduit having a passage communicating with said heated outgoing process gas from said one section and said fresh supply gas and having an end communicating with said one section for conveying said incoming supply gas to said one section.

10. A system in accordance with claim 9 wherein: said temperature responsive means includes a charged bellows situated in said passage and adapted to initiate expansion at a temperature below said first predetermined temperature.

11. A system in accordance with claim 10 wherein: said temperature responsive means further includes: a first damper responsive to said bellows and arranged to allow, respectively, said first and second amounts of said outgoing heated gas from

said one section and said fresh supply to reach said end of said passage.

12. A system in accordance with claim 11 wherein:

said conduit includes first and second conduit portions; said first conduit portion having first and second ports and third and fourth ports situated between said first and second ports, said second and third ports communicating with said outgoing heated process gas from said one section and said fresh supply gas, respectively, and said fourth port being situated between said second and third ports and being connected to said second conduit portion which extends from said fourth port to said one section;

said first damper is movable between said fourth and second ports;

said bellows is situated in said first conduit portion;

and said temperature responsive means further includes a second damper responsive to said bellows and movable into and out of engagement with said first port.

13. A system in accordance with claim 12 wherein:

said bellows causes said first and second dampers to sealingly close said second and first ports, respectively, when the temperature of said outgoing process gas from said one section, is below a second predetermined temperature lower than said first predetermined temperature.

14. A system in accordance with claim 13 wherein: said second damper is movably supported in said first conduit portion between a first position in which it sealingly engages said first port and a second position in which it is disengaged from said first port;

said first damper is movably supported within said first conduit portion between a first position in which it sealingly engages said first conduit portion adjacent one end of said fourth port and a second position in which it sealingly engages said first conduit portion adjacent the other end of said fourth port.

15. A system in accordance with claim 14 wherein: said first damper sealingly engages said second port in said second position.

16. A system in accordance with claim 14 in which: said dampers are in said first positions when the temperature of the outgoing heated process gas of said one section is below said second predetermined temperature and in said second positions when the temperature of the outgoing heated process gas is above a third predetermined temperature higher than said first predetermined temperature.

17. A system in accordance with claim 16 wherein: said system further includes means for connecting said dampers to said bellows;

and said expansion of said bellows is sufficient to move said dampers from said first to said second positions during a change in the temperature

of said process gas from said second to said third predetermined temperatures.

18. A system in accordance with claim 17 wherein:

said bellows is fluid charged.

19. A system in accordance with claim 17 wherein:

said bellows is rigidly fixed at one end and moveable at its other end;

and said connecting means connects each damper to said other end of said bellows.

20. A system in accordance with claim 19 wherein:

said connecting means includes:

first and second connecting rods, said first connecting rod being connected to one of said dampers and said second connecting rod being connected to the other other of said dampers;

and means for coupling said first and second connecting rods to said other end of said bellows.

21. A system in accordance with claim 20 wherein:

said coupling means comprises a yoke assembly.

22. A system in accordance with claim 21 wherein:

said yoke assembly comprises first and second members connected to and transverse of said first and second rods;

and third and fourth members extending between corresponding ends of said first and second members.

23. A system in accordance with claim 22 further comprising:

a support plate rigidly mounted in said first conduit portion and supporting said fixed end of said bellows;

and first and second bearing plates rigidly mounted in said first conduit portion and slidably supporting said first and second rods.

24. A system in accordance with claim 23 wherein:

said bellows is supported above said third port.

25. A system in accordance with claim 24 wherein:

said second damper is external of said first conduit portion.

26. A system in accordance with claim 25 further comprising:

first sealing means arranged to border the periphery of said first port and second and third sealing means arranged to border the inner periphery of said first conduit portion adjacent the respective ends of said fourth port and engaged by said first and second dampers when in said first positions and said second damper when in said second position.

27. A system in accordance with claim 26 wherein:

each of said sealing means is an O-ring.

28. A method of producing electrical energy through electrochemical reaction in a fuel cell having anode and cathode sections adapted to receive incoming process gas comprising the steps of:

combining a first amount of heated process gas outgoing from one of said sections with a second amount of fresh supply process gas to form the incoming process gas for that one section;

adjusting said first and second amounts in dependence on the temperature of said outgoing

gas from that one section to maintain the temperature of said cell at a first predetermined temperature.

29. A method in accordance with claim 28 wherein:

said supply gas is at a temperature below that of said heated process gas.

30. A method in accordance with claim 29 wherein:

said supply gas is at ambient temperature.

31. A method in accordance with claim 28 wherein:

said step of adjusting is carried out as to maintain the incoming gas to said one section at a substantially constant flow level.

32. A method in accordance with claim 28 wherein:

said substantially constant flow level is above that required to provide a predetermined output potential of said fuel cell at said first predetermined temperature.

33. A method in accordance with claim 28 wherein:

said step of adjusting is carried out by varying said first amount from values equal to or greater than zero and by varying said second amount from values equal to or greater than zero.

34. A method in accordance with claim 28 wherein:

said one section is said cathode section.

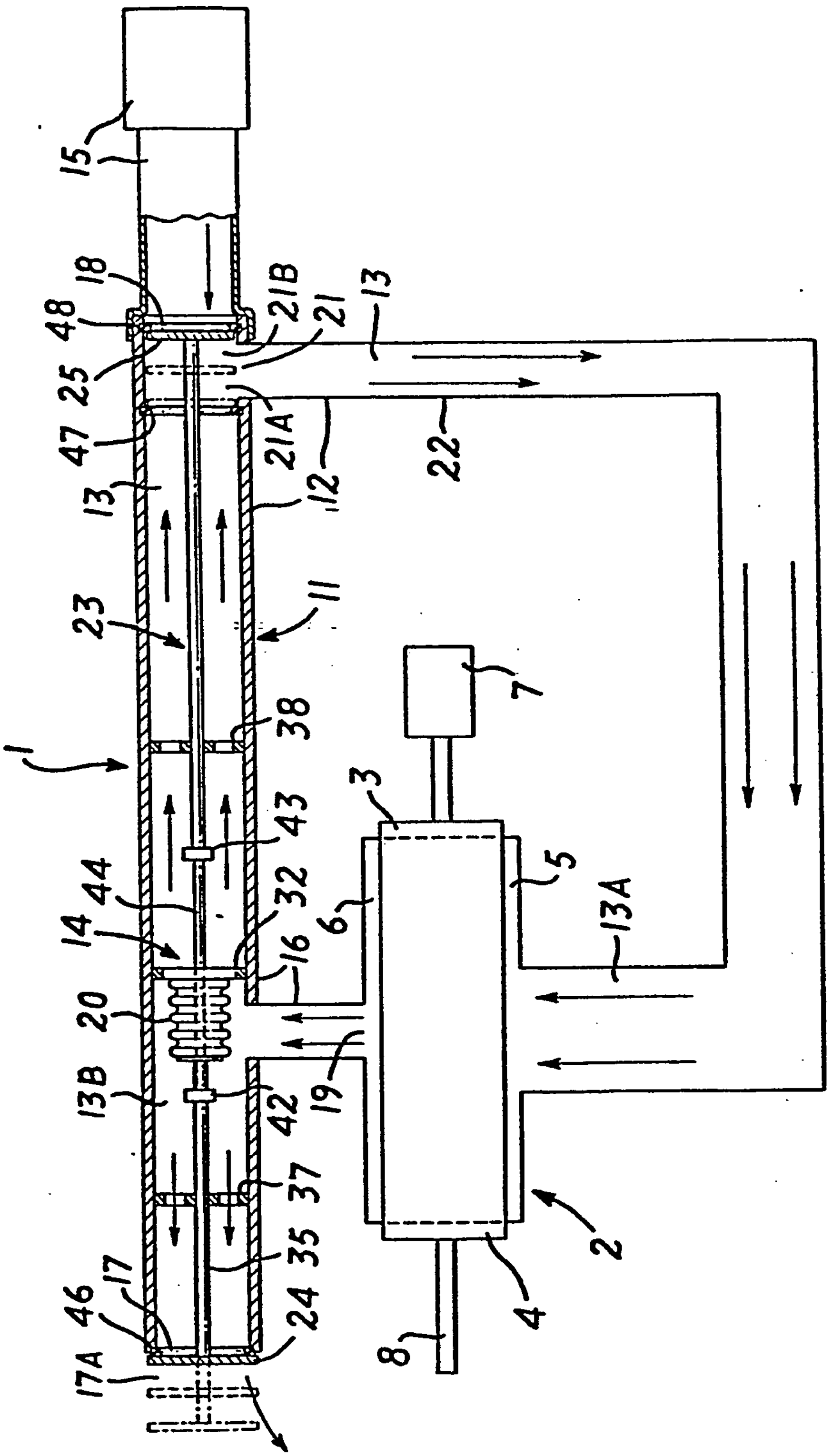

FIG. 1

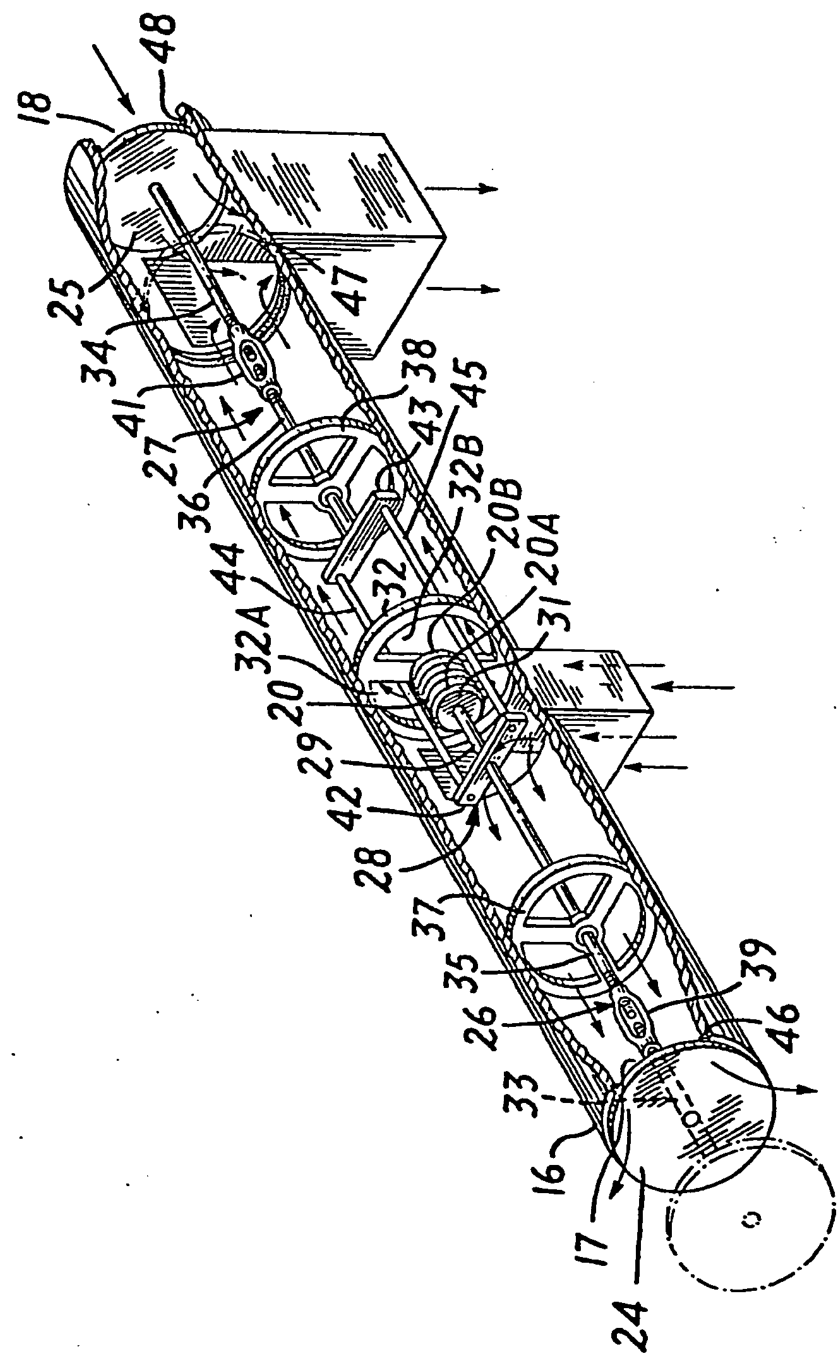
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FIG. 2

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(56) References cited:
FR-A-1 347 259
FR-A-1 439 600
FR-E- 83 568
GB-A-2 025 119
US-A-3 473 963
US-A-3 523 830
US-A-3 576 677
US-A-3 716 415
US-A-3 956 016

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Description

The invention relates to an apparatus and a method for maintaining a fuel cell at a predetermined temperature wherein the incoming process gas to the cell is provided by combining a first amount of heated process gas outgoing from the cell with a second amount of fresh process gas. Dampers control the outgoing portion of a heated gas stream and an incoming fresh gas stream and the incoming gas stream is combined with the remaining portion of the heated gas stream to maintain the temperature of the cell at the predetermined temperature.

Such an apparatus and such a method which correspond to the prior art portions of claims 1 and, respectively, claim 19, are known from US—A—3 473 963 wherein the fuel cell is cooled by the combined incoming gas stream and the remaining portion of the heated gas stream, the oxidant process gas also being taken from these combined gas streams. These combined gas streams are heated by the fuel cell and the outgoing portion of this heated gas stream is replaced by an incoming fresh gas stream, the respective portions being controlled by the dampers in response to the temperature of the used oxidant process gas. The used oxidant process gas itself is partly combined with fresh oxidant process gas and partly leaves the apparatus with the respective portions being fixed.

It is known from GB—A—2 025 119 to utilize the sensible heat from the process gas itself for the thermal control of the fuel cell. With this technique, the incoming process gas may be supplied to the fuel cell at a temperature below the desired cell operating temperature and at a flow level above that required to obtain a preselected cell output power. The additional process gas at the lower temperature then acts to remove heat simply by increasing its temperature during passage through the cell. In this type of system, it is also usual to recover unused outgoing heated process gas and, after suitable cooling and water removal, to add the same to the fresh supply gas to provide the required in-flow of process gas to the cell.

It is known from FR—E—83 568 to control the volume and the temperature of the respective amounts of process gas which are discharged from and remained in the fuel cell in response to the temperature of the fuel cell and the recycled process gas conduit in order to produce a predetermined output power.

The invention as claimed in claims 1 and 17 solves the problem of how to maintain a fuel cell at a predetermined temperature in a simple, passive and automatic manner by adjusting the amount of heated process gas outgoing from the anode or cathode section and the amount of fresh process gas in dependence on the temperature of the outgoing gas from the anode or, respectively, cathode section and by combining these amounts of heated and fresh process gas to form the incoming process gas for said anode or, respectively, cathode section. The adjustment of the amounts of outgoing heated process gas and fresh process gas is effected by a charged bellows whose expansion and contraction controls a damper assembly which effects passage of the amounts of heated process gas and fresh process gas through a conduit passage to the cell input manifold. The conduit has a passage in communication with the input and output manifolds of the cell and with the source of fresh process gas.

One of the advantages offered by the invention is the automatic hermetic sealing of the fuel cell during non-operating periods.

One way of carrying out the invention is described in detail below with reference to drawings, in which:

FIG. 1 illustrates schematically an electrochemical cell system in accordance with the principles of the present invention; and

FIG. 2 shows in greater detail the temperature control system of the cell system of FIG. 1.

Detailed Description

In FIG. 1, electrochemical cell system 1 comprises a fuel cell stack 2 having corresponding sets of input and output manifolds 3 and 4 and 5 and 6, respectively, serving the anode and cathode sides of the stack. Input manifold 3 receives process gas (fuel gas) from a fuel supply 7 and conveys same as incoming fuel gas to the stack 2. Unused outgoing fuel gas is expelled through output manifold 4 to an exhaust conduit 8. Further process gas (oxidant gas) is received by the input manifold 5 which conveys same as incoming oxidant gas to the stack, while unused oxidant gas outgoing from the cell is expelled from the output manifold 6.

Attendant the operation of the stack 2 to provide a predetermined or desired output electrical power through electrochemical reaction of the fuel and oxidant gases, is the production of heat which increases with continued cell operation. This heat, if not maintained at a predetermined temperature associated with the desired cell output power, will cause a reduction in output power and eventual destruction of the stack 2. Accordingly, a temperature control system 11 is provided to ensure maintenance of the cell temperature at the predetermined level.

In accordance with the principles of the present invention, the system 11 provides temperature control through forming the incoming process gas from a combination of respective amounts of outgoing heated process gas and fresh supply process gas, these amounts being automatically adjusted to ensure cell temperature at the predetermined level. In the present illustrative example, temperature control is brought about by forming the incoming oxidant process gas from first and second amounts of outgoing heated oxidant process gas and fresh supply oxidant process gas. However, it is within the contemplation of the invention to provide such control by establishing the incoming fuel process gas or both the incoming fuel process gas and the

incoming oxidant process gas in such manner. Where fuel process gas control is to be provided, a system similar to that to be described for the system 11 can be used.

The system 11 comprises a conduit 12 having a passage 13 whose one end 13A communicates with the input manifold 5 and whose other end 13B communicates with the output manifold 6. Temperature responsive means 14 situated in the passage 13 is responsive to the temperature of the outgoing heated oxidant gas from the output manifold 6 and controls the amount of such gas and the amount of fresh supply oxidant gas from a supply 15 to be coupled to the passage end 13A and, therefore, to the input manifold 5.

More particularly, referring both to FIGS. 1 and 2, the conduit 12 has first and second opposite ends 18, 17, the first end 18 being fed by the supply 15 and the second end 17 serving to exhaust the portion of the outgoing heated oxidant gas not utilized to form the incoming oxidant gas. First and second intermediate ports 21 and 19 are also provided in the conduit 12. The second port 19 communicates with the output manifold 6 and receives the outgoing heated oxidant gas from the stack 2. The first port 21 couples respective portions of the outgoing heated oxidant gas and the fresh supply oxidant gas to a conduit 22. Conduit 22 extends from the first port 21 to the input manifold 5.

Temperature responsive means 14 controls the relative amounts of outgoing heated oxidant gas and fresh supply oxidant gas coupled through first port 21 by adjusting the respective access regions 21A and 21B of the first port 21, and by simultaneously adjusting the exhaust region 17A of the second end 17. More particularly, the control means 14 comprises a fluid charged bellows 20 which operates a damper assembly 23 comprised of first and second dampers 25 and 24 situated adjacent first port 21, respectively. Damper 24 is of area sufficient to totally block the end 17 when in abutting relationship thereto. As shown, the damper 24 is disposed exterior to the conduit 12 and defines with the end 17 the exhaust region 17A. Damper 25, in turn, is of area equal to the cross sectional area of the conduit 12 and defines with the port 21 the access regions 21A and 21B.

As seen more clearly in FIG. 2, the damper assembly 23 further includes component structure for supporting the dampers 24 and 25 and for interconnecting same to the bellows 20. Thus, first and second tie rod assemblies 26 and 27 connect the dampers 24 and 25 to a yoke assembly 28 which is connected through an actuating rod 29 to an actuator plate 31 carried by the free end 20A of the bellows 20. The other end 20B of the bellows is held fixed by a support plate 32 which is rigidly held against the inner wall of the conduit 12. The tie rod assemblies 26 and 27 are of similar construction and comprise first rod sections 33, 34 connected to the respective dampers 24, 25 and second rod sections 35, 36 connected to the yoke assembly 28. Bearing plates 37, 38 slidably support the rod sections 33, 34 to permit adjustment of the tie rod length. The rod sections 35, 36 connect to yoke assembly 28 transverse members 42, 43 which, in turn, are coupled by connecting rods 44, 45. The latter pass through apertures 32A, 32B in the support plate 32, while the transverse member 42 is further connected to the actuating rod 29.

As further shown in FIG. 1, an O-ring 46 is provided in contiguous relationship with the inner wall of the conduit 12 at the second end 17 to provide an effective seal when the damper 24 is in engaging relationship with the end 17. Similarly, O-rings 47, 48 are provided contiguous the conduit 12 inner wall adjacent opposite ends of the first port 21. These rings are engaged by the damper 25 when at such port ends to thereby effect a gas seal thereat.

As above-indicated, the temperature control system 11 provides control of the stack 2 temperature by controlling the respective amounts of outgoing oxidant gas and oxidant supply gas coupled through the access regions 21A and 21B and combined in the conduit 22 for passage to the passage end 13A adjacent the cell input port 5. In practice, the bellows 20 is designed to undergo expansion at a temperature above the minimum reaction temperature of the cell. A typical temperature at which bellows 20 expansion begins might be 122°C (250°F) for a cell having a minimum reaction temperature of 107°C (225°F). Moreover, the conduits 16 and 22 are selected to establish flow in excess of that required for electrochemical reaction at the predetermined cell temperature which might, for example, be 163°C (325°F). The oxidant supply is typically air, preferably, at ambient temperature (e.g., about 22°C (72°F)).

In operation, the fuel cell stack 2 is initially at rest with no process gas flow therethrough and, thus, in an unheated condition. The oxidant gas at the bellows 20 is, therefore, likewise unheated and the bellows 20 is in its maximum contracted position. In this position, the actuating rod 29 and yoke assembly 28 move the respective rod assemblies 26 and 27 rightward thereby moving the dampers 24 and 25 into sealing engagement with the O-rings 46 and 48. The access regions 17A and 21B are thereby reduced to zero expanse and the access region 21A to maximum expanse. In this condition, the cathode side of the stack 2 is placed in an hermetically sealed condition.

To bring the fuel cell into operation, the oxidant gas initially in the conduit 22 is preheated by a heat exchanger (not shown) situated in the conduit 22 to the cell reaction temperature and a blower (also not shown) in the conduit 22 causes circulation of the heated oxidant gas and, therefore, application of the gas as incoming oxidant gas to the stack 2. Fuel gas is then supplied to the stack 2 manifold for passage through the stack.

Due to electrochemical reaction, the stack 2 produces electrical energy from the incoming oxidant and fuel gases. As a product of this reaction, heat is generated by the cell 2 causing a

heating of unused oxidant gas outgoing from the cell 2 through manifold 6. This gas passes through the port 19 into the conduit 12 and, in doing so, contacts the bellows 20, which, in the case shown, is directly above the port 19. Since the bellows 20 does not begin to expand until raised to a temperature above the stack minimum reaction temperature, the bellows remains in its contracted position as initial outgoing heated oxidant gas passes through the conduit 16. At this time, the dampers 24 and 25 remain in their initial positions, maintaining the access region 21A at its maximum expanse and the access region 21B and exhaust region 17A at their minimum zero expanses.

As the stack 2 continues to operate, the stack 2 temperature increases above the temperature at which the bellows 20 expands. At this point, the outgoing oxidant gas, which now also is at this increased temperature, in contacting the bellows 20 causes expansion thereof. Such expansion results in leftward movement of the free end 20A of the bellows 20 and, accordingly, leftward movement of the dampers 24 and 25 through actuating rod 29, yoke assembly 28 and rod assemblies 26 and 27. The dampers 24, 25 are thus moved leftward of the O-rings 46 and 48, causing the exhaust region 17A to increase from its minimum zero expanse and the access region 21A to decrease from its maximum expanse. A portion of the outgoing heated oxidant gas is thus expelled from the conduit 12 through the region 17A, while the remaining part is carried by the conduit 12 to the access region 21A. At the same time, the access region 21B is increased from its minimum zero expanse allowing fresh supply oxidant gas to pass through this region.

The heated oxidant gas and the fresh supply gas pass through the respective regions 21A and 21B and into the conduit 22. The gases are combined therein to form a composite gas which is now at a lower temperature than the outgoing heated oxidant gas, the combined gas being conveyed by the conduit 22 to the manifold 5 as incoming oxidant gas.

The aforementioned process continues until the bellows 20 expands to a position whereat the dampers 24 and 25 are positioned to provide an exhaust region 17A and access regions 21A and 21B of expanses which proportion the amounts of heated oxidant gas returned and exhausted and the amount of fresh supply gas taken in to result in a temperature equilibrium in the stack 2 at the preselected temperature. When this condition ensues, the stack temperature remains at the preselected temperature and the heated outgoing oxidant gas ceases to increase in temperature. The bellows 20 thus stops expanding and maintains the equilibrium positions of the dampers 24 and 25 and, therefore, the respective relationship of the regions 17A, 21A and 21B. The amount of heated outgoing oxidant gas and fresh supply gas combined in the conduit 22 is thereby held constant, as is temperature of the combined gas as it is applied to the cell 2 at the input manifold 5.

Any additional increases in temperature of the cell 2 are now manifested as temperature increases in the outgoing heated oxidant gas which causes further expansion of the bellows 20. This results in further increasing the expanse of exhaust region 17A, further decreasing the expanse of access region 21A, and further increasing the expanse of access region 21B. Less heated outgoing oxidant gas and additional fresh supply gas at the lower temperature are thereby fed into the conduit 22, whereby the temperature of the composite gas is lowered sufficiently to lower the stack temperature. This continues until the stack temperature returns to the preselected temperature, at which time the bellows 20 will have contracted and moved the dampers 24, 25 to their respective equilibrium positions.

If the stack temperature now should decrease below the preselected temperature, the opposite operation occurs. Thus, the bellows 20 is further contracted causing rightward movement of the dampers 24, 25, thereby decreasing the expanses of regions 17A and 21B and increasing the expanse of region 21A. This reduces the amount of outgoing oxidant gas exhausted, increases the amount of such gas recirculated and decreases the amount of fresh supply oxidant gas taken in. The composite gas in conduit 22 is thus increased in temperature, thereby increasing the stack 2 temperature. Again this continues until the stack 2 temperature is at the preselected temperature, at which temperature the bellows 20 brings the dampers 24, 25 to their equilibrium positions.

As can be appreciated, the temperature control system 11 of the invention thus acts to control temperature of the stack 2 by adjusting the relative amounts of outgoing heated oxidant gas and lower temperature fresh supply gas which are combined for use as incoming oxidant gas to the stack. Once equilibrium is reached, temperature control occurs through raising and lowering the temperature of the composite gas whose flow remains essentially constant but whose relative proportions of heated and fresh supply oxidant gas varies. Moreover, the aforesaid variation occurs automatically through a bellows and damper assembly which with the stack inoperative also provides hermetic sealing.

With the present system, the fresh supply of oxidant gas need not itself be heated, since heating occurs through combination with the outgoing heated oxidant gas. Thus, as above-indicated, the fresh supply may be at ambient temperature.

The bellows utilized with the present invention may be gas, liquid or otherwise charged and may be biased so as to provide expansion at the required temperatures.

Claims

1. Apparatus for maintaining a fuel cell (2) at a first predetermined temperature, the fuel cell having a cathode section and an anode section for receiving incoming gases, the apparatus com-

prising a conduit (12) having a first end (18) connectable to a supply of fresh process gas, a second end (17) for the discharge of exhausted process gas, and first and second intermediate ports, the first intermediate port (21) being connected by a conduit (22) to the input side of the fuel cell (2) and the second intermediate port (19) being connected by a conduit (16) to the exhaust side of the fuel cell (2), and further comprising means (14) responsive to the temperature of the exhausted process gas for adjusting first and second dampers (25, 24) to control the amounts of exhausted process gas passing to the second conduit end (17) and the first intermediate port (21), respectively, and to control the amount of fresh process gas passing to the first intermediate port (21) to maintain the temperature of the cell at the first predetermined temperature, characterized in that the temperature responsive means (14) contains a charged bellows (20) situated in the conduit (12) adjacent the second intermediate port (19) and adapted to initiate expansion at a temperature below said first predetermined temperature; the first and second dampers (25, 24) are supported in said conduit (12) and movable with the expansion of the bellows (20), said second damper (24) being movable into and out of engagement with said second conduit end (17) and the first damper (25) being adjacent said first conduit end (18) and said first intermediate port (21) and being movable by the bellows (20).

2. Apparatus in accordance with claim 1, wherein said bellows (20) is responsive to temperatures above the minimum reaction temperature of the fuel cell.

3. Apparatus in accordance with claim 1 wherein:

said bellows (20) is adapted to cause said first and second dampers (25, 24) to sealingly close said first and second conduit ends (18, 17), respectively, when the temperature of said exhausted process gas is below a second predetermined temperature lower than said first predetermined temperature.

4. Apparatus in accordance with claim 3 wherein:

said second damper (24) is movably supported in said conduit (12) between a first position in which it sealingly engages said second conduit end (17) and a second position in which it is disengaged from said second conduit end (17);

said first damper (25) is movably supported within said conduit (12) between a first position in which it sealingly engages said conduit (12) adjacent one end of said first intermediate port (21) and a second position in which it sealingly engages said conduit (12) adjacent the other end of said first intermediate port (21).

5. Apparatus in accordance with claim 4 wherein:

said first damper (25) sealingly engages said first conduit end (18) in said second position.

6. Apparatus in accordance with claim 4 in which said bellows is adapted so that said dampers (25, 24) are in said first positions when the temperature of the exhausted process gas is below said second predetermined temperature and in said second positions when the temperature of the exhausted process gas is above a third predetermined temperature higher than said first predetermined temperature.

7. Apparatus in accordance with claim 6 wherein:

said apparatus further includes means for connecting said dampers (25, 24) to said bellows (20) so that said expansion of said bellows (20) is sufficient to move said dampers (25, 24) from said first to said second positions during a change in the temperature of said process gas from said second to said third predetermined temperatures.

8. Apparatus in accordance with claim 7 wherein:

said bellows (20) is rigidly fixed at one end and movable at its other end;

and said connecting means connects each damper (25, 24) to the movable end of said bellows (20).

9. Apparatus in accordance with claim 8 wherein:

said connecting means includes:

first and second connecting rods (26, 27), said first connecting rod (26) being connected to one of said dampers (24) and said second connecting rod (27) being connected to the other of said dampers (25);

and means coupling said first and second connecting rods (26, 27) to said other end of said bellows (20).

10. Apparatus in accordance with claim 9 wherein:

said coupling means comprises a yoke assembly (28).

11. Apparatus in accordance with claim 10 wherein:

said yoke assembly (28) comprises first and second members (42, 43) connected to and transverse of said first and second rods (26, 27);

and third and fourth members (44, 45) extending between corresponding ends of said first and second members (42, 43).

12. Apparatus in accordance with claim 11 further comprising:

a support plate (32) rigidly mounted in said first conduit portion (16) and supporting said fixed end of said bellows (20);

and first and second bearing plates (37, 38) rigidly mounted in said first conduit portion (16) and slidably supporting said first and second rods (26, 27).

13. Apparatus in accordance with claim 12 wherein:

said bellows (20) is supported above said third port (19).

14. Apparatus in accordance with claim 13 wherein:

said second damper (24) is external of said conduit (12).

15. Apparatus in accordance with claim 14 further comprising:

first sealing means (46) arranged to border the

periphery of said second conduit end (17) and second and third sealing means (47, 48) arranged to border the inner periphery of said conduit (12) adjacent the respective ends of said first intermediate port (21) and engaged by said first and second dampers (25, 24) when in said first positions and said first damper (25) when in said second position.

16. Apparatus in accordance with claim 15 wherein:

each of said sealing means is an O-ring.

17. A method of maintaining a fuel cell, having anode and cathode sections adapted to receive incoming process gas, at a predetermined temperature level using the apparatus of any one of claims 1 to 16, wherein the step of controlling the amounts of exhausted process gas and fresh process gas passing to the first intermediate port (21) is automatically carried out characterized in that said charged bellows (20) are located and arranged so as to adjust the amounts of exhausted process gas and fresh process gas in dependence on the temperature of said exhausted process gas.

18. A method in accordance with claim 17 wherein:

said supply gas is provided at a temperature below that of said exhausted process gas.

19. A method in accordance with claim 18 wherein:

said supply gas is provided at ambient temperature.

20. A method in accordance with claim 17 wherein:

said apparatus is arranged so as to maintain the gas passing to said first intermediate port (21) at a substantially constant flow level.

21. A method in accordance with claim 20 wherein:

said substantially constant flow level is above that required to provide a predetermined output potential of said fuel cell at said first predetermined temperature.

22. A method in accordance with claim 17 wherein:

said bellows (20) are so located and arranged that they can adjust the amount of fresh process gas from values equal to or greater than zero and the amount of exhausted process gas from values equal to or greater than zero.

23. A method in accordance with claim 17 wherein:

said first intermediate port (21) is connected to cathode section.

Patentansprüche

1. Vorrichtung, um eine Brennstoffzelle (2) bei einer ersten vorgegebenen Temperatur zu halten, wobei die Brennstoffzelle einen Kathodenabschnitt und einen Anodenabschnitt zur Aufnahme eintretender Gase aufweist, mit einer Leitung (12), die ein erstes Ende (18), das mit einer Quelle für frisches Verfahrensgas verbindbar ist, ein zweites Ende (17) zur Ableitung des verbrauchten Verfahrensgases und erste und zweite Zwischenöffnungen aufweist, wobei die erste Zwischenöffnung (21) durch eine Leitung (22) mit der Einlaßseite der Brennstoffzelle (2) verbunden ist und die zweite Zwischenöffnung (19) durch eine Leitung (16) mit der Auslaßseite der Brennstoffzelle verbunden ist, und ferner mit einer Einrichtung (14), die auf die Temperatur des verbrauchten Verfahrensgases anspricht, um zur Steuerung der Menge des zum zweiten Leitungsende (17) bzw. der ersten Zwischenöffnung (21) durchgelassenen verbrauchten Verfahrensgases und zur Steuerung der Menge des zur ersten Zwischenöffnung (21) durchgelassenen frischen Verfahrensgases erste und zweite Schieber (25, 24) einstellt, um die Temperatur der Zelle bei der ersten vorgegebenen Temperatur zu halten, dadurch gekennzeichnet, daß die auf die Temperatur ansprechende Einrichtung (14) einen gefüllten Faltenbalg (20) aufweist, der in der Leitung (12) nahe der zweiten Zwischenöffnung (19) angeordnet ist und sich bei einer Temperatur unterhalb der ersten vorgegebenen Temperatur ausdehnt, wobei die ersten und zweiten Schieber (25, 24) in der Leitung (12) abgestützt sind und mit der Ausdehnung des Faltenbalgs (20) bewegbar sind, der zweite Schieber (24) in und außer Eingriff mit dem zweiten Leitungsende (17) bewegbar ist und der erste Schieber (25) bei dem ersten Leitungsende (18) und der ersten Zwischenöffnung (21) angeordnet ist und durch den Faltenbalg (20) bewegbar ist.

2. Vorrichtung nach Anspruch 1, wobei der Faltenbalg (20) auf Temperaturen oberhalb der minimalen Reaktionstemperatur der Brennstoffzelle anspricht.

3. Vorrichtung nach Anspruch 1, wobei der Faltenbalg (20) in der Lage ist, den ersten und den zweiten Schieber (25, 24) zu veranlassen, das erste bzw. zweite Leitungsende (18, 17) dicht zu verschließen, wenn die Temperatur des verbrauchten Verfahrensgases unterhalb einer zweiten vorgegebenen Temperatur liegt, die niedriger als die erste vorgegebene Temperatur ist.

4. Vorrichtung nach Anspruch 3, wobei der zweite Schieber (24) beweglich in der Leitung (12) zwischen einer ersten Position, in der er in abdichtendem Eingriff mit dem zweiten Leitungsende (17) steht, und einer zweiten Position, in der er außer Eingriff mit dem zweiten Leitungsende (17) steht, beweglich abgestützt ist; und der erste Schieber (25) innerhalb der Leitung (12) zwischen einer ersten Position, in der er in abdichtendem Eingriff mit der Leitung (12) bei einem Ende der ersten Zwischenöffnung (21) steht, und einer zweiten Position, in der er in dichtendem Eingriff mit der Leitung (12) bei dem anderen Ende der ersten Zwischenöffnung (21) steht, verschiebbar abgestützt ist.

5. Vorrichtung nach Anspruch 4, wobei der erste Schieber (25) in dichtendem Eingriff mit dem ersten Leitungsende (18) in der zweiten Position steht.

6. Vorrichtung nach Anspruch 4, wobei der Faltenbalg so ausgebildet ist, daß sich die Schie-

ber (25, 24) in den ersten Positionen befinden, wenn die Temperatur des verbrauchten Verfahrensgases unterhalb der zweiten vorgegebenen Temperatur liegt, und in den zweiten Positionen befinden, wenn die Temperatur des verbrauchten Verfahrensgases oberhalb einer dritten vorgegebenen Temperatur liegt, die höher ist als die erste vorgegebene Temperatur.

7. Vorrichtung nach Anspruch 6, wobei die Vorrichtung ferner eine Einrichtung zum Verbinden der Schieber (25, 24) mit dem Faltenbalg (20) aufweist, so daß die Ausdehnung des Faltenbalgs (20) ausreicht, um die Schieber (25, 24) bei einer Änderung der Temperatur des Verfahrensgases von der zweiten zu der dritten vorgegebenen Temperatur aus der ersten in die zweite Position zu verschieben.

8. Vorrichtung nach Anspruch 7, wobei der Faltenbalg (20) am einen Ende starr befestigt ist und am anderen Ende verschiebbar ist und die Verbindungseinrichtung jeden Schieber (25, 24) mit dem verschiebbaren Ende des Faltenbalgs (20) verbindet.

9. Vorrichtung nach Anspruch 8, wobei die Verbindungseinrichtung erste und zweite Verbindungsstangen (26, 27) aufweist, die erste Verbindungsstange (26) mit einem der Schieber (24) verbunden ist und die zweite Verbindungsstange (27) mit dem anderen der Schieber (25) verbunden ist, sowie eine Einrichtung zum Kuppeln der ersten und zweiten Verbindungsstange (26, 27) an das andere Ende des Faltenbalgs (20).

10. Vorrichtung nach Anspruch 9, wobei die Kupplungseinrichtung eine Jochanordnung (28) aufweist.

11. Vorrichtung nach Anspruch 10, wobei die Jochanordnung (26) erste und zweite Elemente (42, 43), die mit den ersten und zweiten Stangen (26, 27) verbunden sind und quer zu diesen liegen, und dritte und vierte Elemente (44, 45) aufweist, die sich zwischen den entsprechenden Enden der ersten und zweiten Elemente (42, 43) erstrecken.

12. Vorrichtung nach Anspruch 11, mit ferner einer Abstützplatte (32), die starr in dem ersten Leitungsabschnitt (16) montiert ist und das feste Ende des Faltenbalgs (20) abstützt;

und ersten und zweiten Lagerplatten (37, 38), die starr in dem ersten Leitungsabschnitt (16) montiert sind und die ersten und zweiten Stangen (26, 27) verschiebbar abstützen.

13. Vorrichtung nach Anspruch 12, wobei der Faltenbalg (20) oberhalb der dritten Öffnung (19) abgestützt ist.

14. Vorrichtung nach Anspruch 13, wobei sich der zweite Schieber (24) außerhalb der der Leitung (12) befindet.

15. Vorrichtung nach Anspruch 14, mit ferner einer ersten Dichtungseinrichtung (46), die so angeordnet ist, daß sie an den Umfang des zweiten Leitungsendes (17) angrenzt, und einer zweiten und dritten Dichtungseinrichtung (47, 48), die so angeordnet sind, daß sie an den inneren Umfang der Leitung (12) bei den entsprechenden Enden der ersten Zwischenöffnung (21) angrenzen und daß sie in den ersten Positionen im Eingriff mit den ersten und zweiten Schiebern (25, 24) und in der zweiten Position mit dem ersten Schieber (25) stehen.

16. Vorrichtung nach Anspruch 15, wobei jede der Dichtungseinrichtung ein O-Ring ist.

17. Verfahren, um eine Brennstoffzelle mit Anoden- und Kathodenabschnitten, die zur Aufnahme von zugeführtem Verfahrensgas ausgebildet sind, auf einer vorgegebenen Temperatur zu halten unter Verwendung der Vorrichtung nach einem der Ansprüche 1 bis 16, wobei die Steuerung der Mengen von verbrauchtem Verfahrensgas und frischem Verfahrensgas, die die erste Zwischenöffnung (21) passieren, automatisch durchgeführt wird, dadurch gekennzeichnet, daß der gefüllte Faltenbalg (20) so positioniert und angeordnet ist, daß er die Menge von verbrauchtem Verfahrensgas und frischem Verfahrensgas in Abhängigkeit von der Temperatur des verbrauchten Verfahrensgases einstellt.

18. Verfahren nach Anspruch 17, wobei das Gas bei einer Temperatur unter der des verbrauchten Verfahrensgases zugeführt wird.

19. Verfahren nach Anspruch 18, wobei das Gas bei Umgebungstemperatur zugeführt wird.

20. Verfahren nach Anspruch 17, wobei die Vorrichtung so angeordnet ist, daß das die erste Zwischenöffnung (21) passierende Gas auf einem im wesentlichen konstanten Strömungswert gehalten wird.

21. Verfahren nach Anspruch 20, wobei der im wesentlichen konstante Strömungswert oberhalb dessen liegt, der zur Erzeugung einer vorgegebenen Leistungsabgabe der Brennstoffzelle bei der vorgegebenen ersten Temperatur erforderlich ist.

22. Verfahren nach Anspruch 17, wobei der Faltenbalg (20) so positioniert und angeordnet ist, daß er die Menge an frischem Verfahrensgas von Werten gleich oder größer als Null und die Menge an verbrauchtem Verfahrensgas von Werten gleich oder größer als Null einstellen kann.

23. Verfahren nach Anspruch 17, wobei die erste Zwischenöffnung (21) mit dem Kathodenabschnitt verbunden ist.

Revendications

1. Appareil pour maintenir une pile à combustible (2) à une première température prédéterminée, la pile à combustible ayant une partie cathode et une partie anode pour recevoir des gaz entrants, l'appareil comprenant un conduit (12) ayant une première extrémité (18) pouvant être reliée à une alimentation en gaz de réaction frais, une seconde extrémité (17) pour l'évacuation de gaz de réaction mis à l'échappement, et un premier et un second orifices intermédiaires, le premier orifice intermédiaire (21) étant relié par un conduit (22) au côté entrée de la pile à combustible (2) et le second orifice intermédiaire (19) étant relié par un conduit (16) au côté échappement de la pile à combustible (2), et comprenant en outre des moyens (14) sensibles à la

température du gaz de réaction mis à l'échappement pour régler des premier et second clapets (25, 24) afin de commander les quantités de gaz de réaction mixes à l'échappement traversant la seconde extrémité (17) du conduit et le premier orifice intermédiaire (21) respectivement, et pour commander la quantité de gaz de réaction frais circulant vers le premier orifice intermédiaire (21) afin de maintenir la température de la pile à la première température prédéterminée, appareil caractérisé en ce que les moyens (14) sensibles à la température comprennent un soufflet chargé (21) situé dans le conduit (12) au voisinage du second orifice intermédiaire (19) et adapté pour commencer une dilatation à une température au-dessous de ladite première température prédéterminée; les premier et second clapets (25, 24) étant soutenus dans ledit conduit (12) et mobiles avec la dilatation du soufflet (20), ledit second clapet (24) étant mobile en contact et hors de contact avec la seconde extrémité (17) du conduit et le premier clapet (25) étant adjacent à ladite première extrémité (18) du conduit et audit premier orifice intermédiaire (21) et pouvant être déplacé par le soufflet (20).

2. Appareil suivant la revendication 1, dans lequel ledit soufflet (20) est sensible à des températures au-dessus de la température minimale de réaction de la pile à combustible.

3. Appareil suivant la revendication 1 dans lequel ledit soufflet (20) est adapté pour astreindre lesdits premier et second clapets (25, 24) à fermer hermétiquement lesdites première et seconde extrémités (18, 17) du conduit respectivement lorsque la température dudit gaz de réaction mis à l'échappement est inférieure à une seconde température prédéterminée plus basse que ladite première température prédéterminée.

4. Appareil suivant la revendication 3, dans lequel ledit second clapet (24) est soutenu de façon déplaçable dans ledit conduit (12) entre une première position dans laquelle il est en contact de fermeture avec ladite seconde extrémité (17) du conduit et une seconde position dans laquelle il est écarté de ladite seconde extrémité (17) du conduit, ledit premier clapet (25) étant soutenu de façon déplaçable dans ledit premier conduit (12) entre une première position dans laquelle il est en contact de fermeture avec ledit conduit (12) au voisinage d'une extrémité dudit premier orifice intermédiaire (21) et une seconde position dans laquelle il est en contact de fermeture avec ledit conduit (12) au voisinage de l'autre extrémité dudit premier orifice intermédiaire (21).

5. Appareil suivant la revendication 4, dans lequel ledit premier clapet (25) est en contact de fermeture avec ladite première extrémité (18) du conduit dans ladite seconde position.

6. Appareil suivant la revendication 4, dans lequel ledit soufflet est adapté de façon que lesdits clapets (25, 24) se trouvent dans lesdites premières positions lorsque la température des gaz de réaction sortants est inférieure à ladite seconde température prédéterminée et se trouvent dans lesdites secondes positions lorsque la température du gaz de réaction sortant est supérieure à une troisième température prédéterminée plus élevée que ladite première température prédéterminée.

7. Appareil suivant la revendication 6, dans lequel ledit appareil comprend en outre des moyens pour relier lesdits clapets (25, 24) audit soufflet (20) de façon que ladite dilatation du soufflet (20) soit suffisante pour déplacer lesdits clapets (25, 24) depuis ladite première jusqu'à ladite seconde position pendant un changement de la température dudit gaz de réaction passant de la dite seconde à la troisième températures prédéterminées.

8. Appareil suivant la revendication 7 dans lequel ledit soufflet (20) est fixé rigidement à une extrémité et est mobile à son autre extrémité, et lesdits moyens de liaison relient chaque clapet (25, 24) à l'extrémité mobile dudit soufflet (20).

9. Appareil suivant la revendication 8 dans lequel lesdits moyens de liaison comprennent une première et une seconde tiges de liaison (26, 27), ladite première tige de liaison (26) étant reliée à l'un (24) desdits clapets et ladite seconde tige de liaison (27) étant reliée à l'autre desdits clapets (25), et des moyens pour coupler lesdites première et secondes tiges de liaisons (26, 27) à ladite autre extrémité dudit souflet (20).

10. Appareil suivant la revendication 9, dans lequel lesdits moyens de couplage sont constitués par un ensemble (28) d'étrier.

11. Appareil suivant la revendication 10, dans lequel ledit ensemble (28) d'étrier comprend un premier et un second organes (42, 43) reliés auxdites première et seconde tiges (26, 27) et transversalement à celles-ci; et un troisième et un quatrième organes (44, 45) s'étendant entre des extrémités correspondantes desdits premier et second organes (42, 43).

12. Appareil suivant la revendication 11, comprenant en outre un support (32) fixé rigidement dans ladite première partie (16) du conduit et soutenant ladite extrémité fixe dudit soufflet (20); et une première et une seconde plaques de portée (37, 39) fixées rigidement dans ladite première partie (16) du conduit et soutenant à coulissement lesdites première et secondes tiges (26, 27).

13. Appareil suivant la revendication 12, dans lequel ledit soufflet (20) est soutenu au-dessus dudit troisième orifice (19).

14. Appareil suivant la revendication 13, dans lequel ledit second clapet (24) est extérieur audit conduit (12).

15. Appareil suivant la revendication 13, comprenant en outre des premiers moyens de fermeture (46) agencés pour garnir la périphérie de ladite seconde extrémité (17) du conduit et des second et troisième moyens de fermeture (47, 48) agencés pour garnir la périphérie interne dudit conduit (12) au voisinage des extrémités respectives dudit premier orifice intermédiaire (21) et en contact avec lesdits premier et second clapets (25, 24) lorsqu'ils se trouvent dans lesdites premières positions et avec ledit premier clapet (25) lorsqu'il se trouve dans la seconde position.

16. Appareil suivant la revendication 15 dans lequel chacun desdits moyens de fermeture est une bague circulaire.

17. Procédé pour maintenir à un niveau de température prédéterminé une pile à combustible comportant des parties anode et cathode adaptées pour recevoir un gaz de réaction entrant, en utilisant l'appareil suivant l'une quelconque des revendications 1 à 16, dans lequel la phase de commande des quantités de gaz de réaction mises à l'échappement et de gaz de réaction frais traversant le premier orifice intermédiaire (21) est assurée automatiquement, caractérisé en ce que ledit soufflet chargé (20) est disposé et agencé de manière à ajuster les quantités de gaz de réaction mises à l'échappement et de gaz de réaction frais suivant la température dudit gaz de réaction mis à l'échappement.

18. Procédé suivant la revendication 17, dans lequel ledit gaz d'alimentation est fourni à une température inférieure à celle dudit gaz de réaction mis à l'échappement.

19. Procédé suivant la revendication 18, dans lequel ledit gaz d'alimentation est fourni à température ambiante.

20. Procédé suivant la revendication 17 dans lequel ledit appareil est agencé afin de maintenir le gaz traversant ledit premier orifice intermédiaire (21) à un niveau d'écoulement à peu près constant.

21. Procédé suivant la revendication 20, dans lequel ledit niveau d'écoulement à peu près constant est supérieur à celui nécessaire pour assurer un potentiel de sortie prédéterminé de ladite pile à combustible à ladite première température prédéterminée.

22. Procédé suivant la revendication 17, dans lequel ledit soufflet (20) est disposé et agencé de façon qu'il puisse ajuster la quantité de gaz de réaction frais à partir de valeurs égales à zéro ou supérieures à zéro et la quantité de gaz de réaction mise à l'échappement depuis des valeurs égales à zéro ou supérieures à zéro.

23. Procédé suivant la revendication 17, dans lequel ledit premier orifice intermédiaire (21) est relié à la partie de cathode.

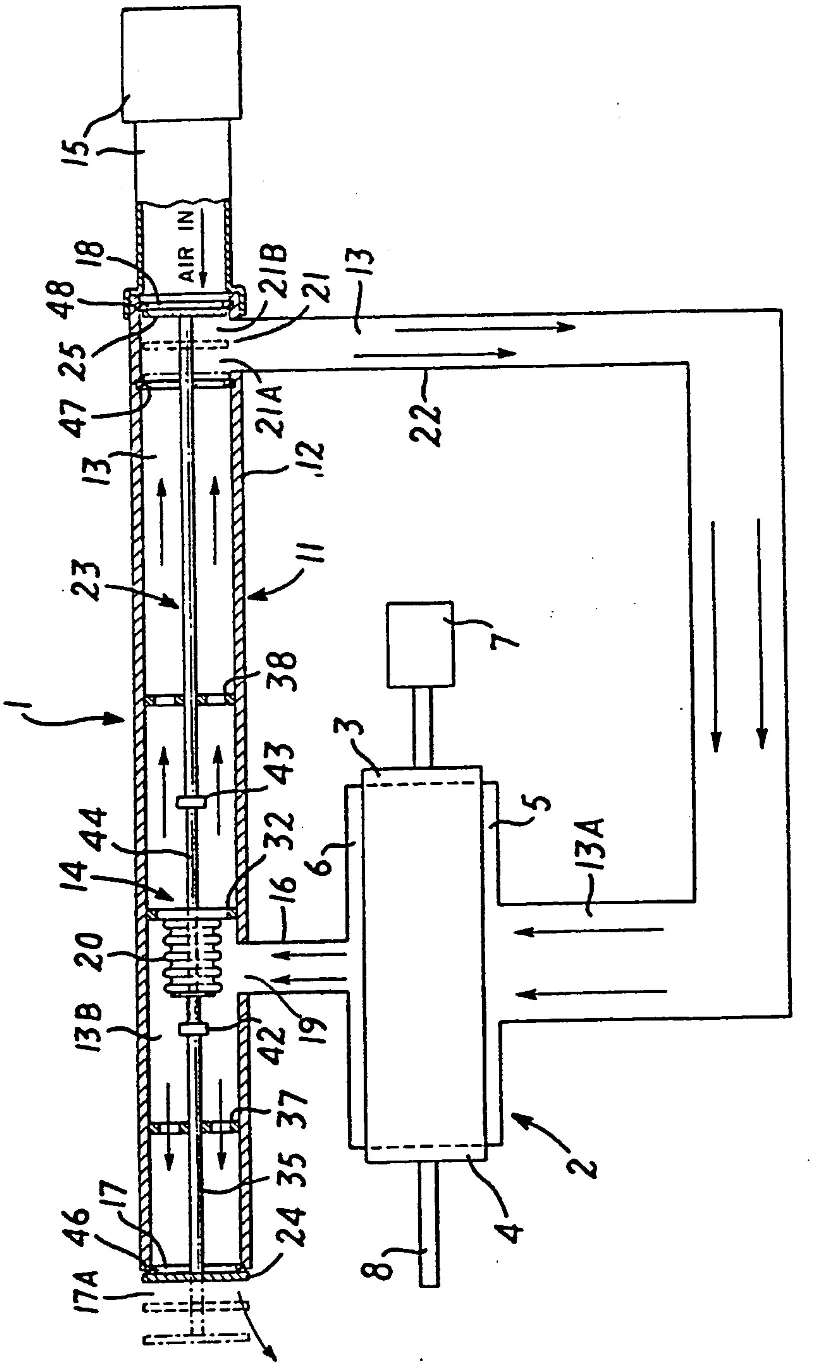
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FIG. 1

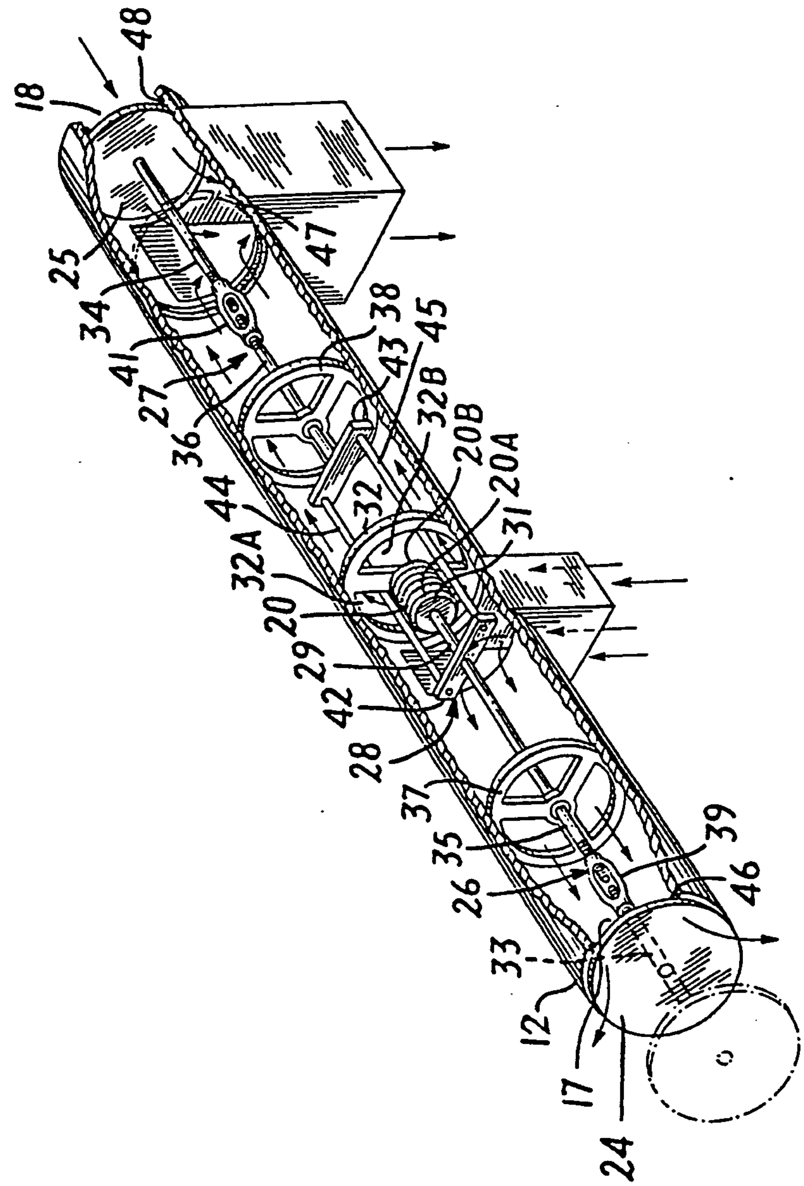
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FIG. 2